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Airway management during in hospital cardiac arrest: an international, multicentre, retrospective, observational cohort study

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Take home message: Not all patients receive advanced airways during in hospital cardiac arrest. There is wide variation in advanced airway strategies between centres.

Abstract

Aim: To determine the type of airway devices used during in-hospital cardiac arrest (IHCA) resuscitation attempts.

Methods: International multicentre retrospective observational study of in-patients aged over 18 years who received chest compressions for cardiac arrest from April 2016 to September 2018. Patients were identified from resuscitation registries and rapid response system databases. Data were collected through review of resuscitation records and hospital notes. Airway devices used during cardiac arrest were recorded as basic (adjuncts or bag–mask), or advanced, including supraglottic airway devices, tracheal tubes or tracheostomies. Descriptive statistics and multivariable regression modelling were used for data analysis.

Results: The final analysis included 598 patients. No airway management occurred in 36 (6%), basic airway device use occurred at any time in 566 (95%), basic airway device use without an advanced airway device in 182 (30%), tracheal intubation in 322 (54%), supraglottic airway in 103 (17%), and tracheostomy in 1 (0.2%). There was significant variation in airway device use between centres. The intubation rate ranged between 21-90% while supraglottic airway use varied between 1-45%. The choice of tracheal intubation vs. supraglottic airway as the second advanced airway device was not associated with immediate survival from the resuscitation attempt (odds ratio 0.81; 95% confidence interval 0.35-1.8).

Conclusion: There is wide variation in airway device use during resuscitation after IHCA. Only half of patients are intubated before return of spontaneous circulation and many are managed without an advanced airway. Further

investigation is needed to determine optimal airway device management strategies during resuscitation following IHCA.

Introduction

Current cardiac arrest guidelines recommend the airway device used during cardiac arrest should be based partly on rescuer expertise.[1-3] Several airway management options are available ranging from none, i.e. chest compression-only cardiopulmonary resuscitation (CPR), to mouth-to-mouth resuscitation, and mouth-to-mask resuscitation, to simple airway manoeuvres or adjuncts with bag–mask ventilation (BMV), and further to advanced airway management with supraglottic airways (SGAs) or tracheal tubes (TTs).[4] Current evidence has failed to determine equivalence or superiority between BMV and advanced airways.[5]

The International Liaison Committee on Resuscitation (ILCOR) has identified the optimal method of ensuring airway patency during in-hospital cardiac arrest (IHCA) as a specific knowledge gap.[6] The choice and timing of an optimal airway device has been debated in the contexts of how to minimise interruptions in chest compressions, the skills required for insertion, optimising cerebral resuscitation and how failed placement may affect overall outcome. An observational cohort study found no support for early tracheal intubation during IHCA[7] whereas a retrospective cohort study indicated a possible benefit.[8] A retrospective study of IHCA suggested improved neurological outcome for those patients who received basic airway management compared with those receiving an advanced airway device.[9] The use of an advanced airway device was associated with lower no flow ratios compared with BMV in a study of one hundred patients during IHCA.[10] A recent analysis of the American Heart Association Get-with-the-Guidelines Resuscitation (AHA GWTG-R) registry demonstrated an inverse association between tracheal intubation during IHCA and survival to hospital discharge, but this finding was confined to patients without preceding respiratory failure.[11] Identifying the optimal approach to airway management for IHCA may have a significant impact on patient survival and neurological outcome but current practice is unclear.

Recent large prospective pre-hospital studies have compared the use of SGAs with TTs during out of-hospital cardiac arrest (OHCA) and found modestly improved survival at 72 hours[12] and comparable functional neurological outcome at 30 days[13,12] among patients treated with an SGA compared with tracheal intubation. It is unclear whether the findings from these studies in OHCA patients can be applied to the management of the airway during IHCA. Very few prospective or randomized studies have been conducted on airway management in IHCA. Data on current practice are needed in order to facilitate such trials. This study aimed to determine current airway device use for patients with IHCA in five centres from four countries.

Methods

This multicentre, international, pragmatic, retrospective observational study was approved by the Ethics and Research Office for the South Western Sydney Local Health District (LNR/19/LPOOL/11, HE 19/5) as the lead site, and subsequent local approval was granted by each of the study centres according to national guidelines. Data was collected from five study centres; Liverpool Hospital (Sydney, Australia), Royal United Hospital Bath (UK), HUS University of Helsinki (Finland), Tampere University Hospital (Finland) and Sahlgrenska University Hospital (Gothenburg, Sweden). The data collection period was April 2016 to September 2018. Patients were identified using local cardiac arrest and medical emergency team (MET) databases. The inclusion criteria were adult patients aged 18 years and over who required chest compressions for a cardiac arrest occurring in hospital. Patients who had a cardiac arrest in the emergency department, operating theatre or intensive care unit (ICU) were excluded from the study as these specialist areas did not always require the assistance of a resuscitation team. Patients with an advanced airway device in situ at the time of arrest and those with missing airway data were also excluded.

All cardiac arrest teams had access to equivalent airway equipment. The i-gel ® was used as the standard SGA in all centres. The minimum advanced airway experience of IHCA first responders is presented in detail in Supplementary Table 1. Capnography was used to confirm advanced airway placement. The airway devices used during the resuscitation attempt before return of spontaneous circulation (ROSC) were recorded from contemporaneous notes or audit forms. The type of first, second and third airway device used during the resuscitation were recorded. The use of a bag-mask with or without airway adjuncts such as an oropharyngeal or nasopharyngeal airway was defined as a basic airway device. Advanced airway devices were sub-categorised as SGAs, TTs or emergency tracheostomies (ETs). The airway devices used were recorded in sequential order wherever possible. We did not include data relating to airway management after ROSC.

Demographic data were collected from electronic medical records and paper medical notes.

The study is reported according to the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement.[14] The study database used for analysis contained absolute minimal data with all patient identifiable data and dates removed in compliance with General Data Protection Regulation (GDPR).

Results are reported as mean and standard deviation or as median and interquartile range as appropriate for normally and non-normally distributed data tested using the Kolmogorov-Smirnov goodness-of-fit test. Comparisons between groups of data were performed using t-test, Mann-Whitney test and chi-square test for continuous and categorical data as appropriate and the odds ratio with the 95% confidence interval reported for the former. A logistic regression analysis of immediate cardiac arrest outcomes (dead vs. alive censored when the resuscitation team was no longer required) was performed for patients who progressed to be managed with a second airway device with age, witnessed or unwitnessed arrest and shockable or non-shockable initial rhythm included a priori as covariates in the model. No formal sample size calculation was performed for this observational study but it was powered to be able to detect a hypothesised 15% variance in airway management between any one centre compared with the aggregate of the others at a power of 90% and a significance level of 0.05 indicating a cohort of 470 patients.[15] The authors professional networks were used to contact centres with necessary detail for the purposes of the study already routinely captured in their cardiac arrest records. No imputations were made for missing data. All statistical analyses were performed using GraphPad Prism version 8.3.0 for MacOS, GraphPad Software (San Diego, CA, USA, www.graphpad.com).

Results

The records of 640 patients were screened for inclusion. Of these 42 patients were excluded as the documentation for their airway data was incomplete, leaving 598 patients for inclusion in the final analysis. The demographic data and outcome of resuscitation attempts for all participants are shown in Table 1. The duration of resuscitation attempt ranged from <1 to 141 minutes. An accurate duration of arrest was unavailable for 69 patients. Standard practice within each centre was to follow internationally recognised resuscitation guidelines.[2,3]

The types and order of airway management used during resuscitation attempts are shown in Table 2. Thirty-six (5.9%) patients received no airway interventions with a median cardiac arrest duration of 2 (2.0-3.8) minutes with 30 patients (83%) alive at the end of resuscitation. Bag-mask ventilation only (with or without airway adjuncts) was used in 122 patients with a median cardiac arrest duration of 4 (2-10) minutes and with 75 patients (61%) surviving the resuscitation attempt. In patients who initially received a basic airway device, 378 (68%) progressed to receive a second airway device with 129 patients (34%) alive after a median cardiac arrest duration of 12 (8-21) minutes. Twenty-six patients (5%) were managed with a third form of airway device during a median cardiac arrest duration of 25 (20-34) minutes with 7 patients (27%) surviving the resuscitation attempt.

The airway devices used by each centre are listed in Table 3. Significant variance between centres was noted for all forms of airway management by comparing the highest/lowest with the next closest rates. The use of a basic airway device at any stage was 4.2 (1.8-9.1) times less likely in centre 5 as compared with centre 2, with use of a basic airway device alone 3.5 (1.6-7.3) less likely in centre 3 compared with centre 5. Tracheal intubation was 5.8 (2.9-11) times more likely in centre 3 compared with centre 4 while the rate of SGA use was not different between centres 1 and 2 ($p=0.45$) although far more frequent compared with centres 3, 4 and 5, similar to using TT for second advanced airway device. No airway intervention was 3.7 (1.6-8.2) times more likely in centre 5 as compared with centre 2.

The flow of airway management for all patients is shown in Figure 1. The overall proportion of patients who were intubated increased with the duration of the resuscitation attempt. Intubation was performed in 19% of patients with an arrest time within the 1st quartile (0-5 minutes), in 48% in the 2nd quartile (6-12 minutes), in 75% in the 3rd quartile (13-23 minutes) and in 87% of patients in the 4th quartile (24-141 minutes). The proportion of patients managed with a basic airway device alone decreased with an increasing resuscitation time.

The logistic regression model for second airway device vs. immediate survival explained 22% of the variance (Nagelkerke R^2) with a negative predictive value of 68% and a positive predictive value of 70% with an overall 69% of cases correctly classified. The choice of TT or SGA as second, advanced airway device was not a significant predictor variable (Table 4).

The flow of airway management in patients who achieved ROSC compared with those where ROSC was not achieved is demonstrated in Figure 2. The variation of airways used in relation to the achievement of ROSC for all patients and excluding those with a short arrest duration (<5 minutes) is shown in Figure 3. The proportion of advanced airway devices in patient with or without ROSC was not different (OR 1.1 (0.78-1.5), p=0.60).

Discussion

This international, multicentre observational study demonstrated considerable variation in the approach taken to airway management during IHCA. While this variation might be expected given the uncertain evidence supporting consensus guidelines, it would also seem plausible that not all strategies for airway management can be considered equal in terms of providing oxygenation and ventilation and ultimately being conducive to ROSC.

The recently published international consensus on cardiopulmonary resuscitation science [16] concluded that the available evidence is not sufficient to recommend using an advanced airway device instead of bag-mask ventilation nor any specific type of advanced airway device during CPR in any setting. The optimal airway management strategy during IHCA was identified as a knowledge gap that requires further investigation.[16, 17] This study supports the need for more rigorous research preferably in the form of randomised controlled trials.

Several patients in this study had short durations of arrest and were managed without a specific airway intervention with a high proportion achieving ROSC. It may therefore be inferred that either resuscitation was successful quickly or a decision was taken to abandon the resuscitation soon after CPR was commenced and there was therefore no reason to insert an advanced airway device.

A recent systematic review of advanced airway management during adult cardiac arrest identified no controlled trials in the IHCA setting while nine observational trials were found.[18] These studies focused on the timing of advanced airway management or comparison of devices and were all deemed to have a critical or serious risk of bias. In a paired case-control analysis based on the AHA GWTG-R registry a 70% intubation rate for IHCA was reported.[7] Using a time-based propensity matching the authors reported lower likelihood for ROSC, lower rate of good neurological outcome and worse survival for patients intubated within the first 15 minutes of IHCA compared with those not intubated in this period. Using the same registry, another group of authors reported that higher intubation rates were associated with reduced survival to hospital discharge rates.[11] Intubation rates varied between 27% and 100% among the 656 hospitals studied. This variation in intubation rates is comparable to the 21-90% found in this study. Interestingly, the use of SGA was less than 1% in the AHA GWTG-R report[11] which is quite different from the 1-40% reported in this study. The reason(s) for using a SGA is unclear but might include being a practical alternative to basic airway techniques, i.e., the airway may be easier to manage with an SGA than with a bag-mask; alternatively, SGA insertion may have been used while awaiting the arrival of a more experienced operator or as a technically easier option to tracheal intubation.

The marked variation among centres in the use of advanced airways, while access to airway equipment during CPR was similar, most likely reflect the proficiency and experience of resuscitation team members managing the airway. The centres with higher tracheal intubation rates ordinarily used personnel with more anaesthetic experience as their first responders. Conversely SGA use was higher in the centres whose personnel may have had less anaesthetic experience, where intubation may have been delayed until definitively needed. We assume the success rate for intubation to be high in this study although data on the number of attempts, the effectiveness of the airway intervention, and any complications were not captured. The proportion of intubated patients was not different in patients who achieved or did not achieve ROSC and in the logistic regression model the use of an advanced airway device (TT or SGA) was not independently associated with survival.

Data from prehospital investigations suggest the majority of cardiac arrest patients have more than one airway intervention.[19] Our data support this as the majority of patients were managed with a basic airway device and a tracheal tube or SGA. It appears that almost all patients received a stepwise approach to their airway management with initial intervention using a basic airway device and subsequent use of advanced techniques when deemed necessary or when appropriate personnel were available. Further review of patients in the cohort who received three airway interventions showed that all but one patient were intubated after SGA insertion suggesting a stepwise approach which considered the invasiveness and necessary pharmacological adjuncts of each airway intervention. The proportion of patients intubated increased as the duration of the resuscitation attempt lengthened. This may reflect the time needed for the resuscitation team to prepare for and perform intubation or a process of clinical evaluation before making the decision to intubate. As in previous studies, a decrease in survival was observed when intubation was performed after prolonged resuscitation.[20]

The skill set and resources available for airway management in hospital differ from those out-of-hospital and therefore caution is warranted when OHCA studies are extrapolated to the IHCA population. The optimal type and duration of training required for specific airway use is unclear and has been identified as a resuscitation knowledge gap.[17] Second generation SGAs enable management of IHCAs without the need for the more advanced training required for tracheal intubation. The timing of airway management in relation to ROSC also needs further study and this study generated insufficient data to explore this issue.

Our observational study does not enable any conclusions about the optimal airway management strategy in relation to clinical outcomes from the resuscitation attempt. We have studied five centres in four countries and this limits the generalisability of our findings. However, we have documented considerable variation in current practice. The ubiquitous use of bag-mask ventilation together with the variable use of advanced airways suggests that a clinical trial of tracheal intubation compared with SGAs for IHCA is both feasible and warranted.

Conclusion

Advanced airway management strategies during IHCA vary between centres. Many patients are not intubated and many are managed without any form of advanced airway device. The likelihood of intubation increases with the duration of arrest. Prospective randomised clinical trials are needed to determine optimal airway management during IHCA.

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Figure 1: Flow of patients managed with different airway devices during resuscitation for in-hospital cardiac arrest. Nodes (bold lines) represent airway interventions.
Basic airway included naso-/oropharyngeal adjuncts and bag-mask ventilation; Tracheal intubation (TT); Supraglottic airway (SGA), Emergency tracheostomy (ET)

Figure 2: Flow of patients managed with different airway devices during resuscitation for in-hospital cardiac arrest. Patients who achieved ROSC (a) versus patients who did not achieve ROSC (b).
Basic airway included naso-/oropharyngeal adjuncts and bag-mask ventilation; Tracheal intubation (TT); Supraglottic airway (SGA), Emergency tracheostomy (ET)

Figure 3. Airway management in patients who did or did not achieve return of spontaneous circulation (ROSC) including all patients (a) and those with a cardiac arrest duration < 5 minutes (b)
Basic airway included naso-/oropharyngeal adjuncts and bag-mask ventilation; Tracheal intubation (TT); Supraglottic airway (SGA), Emergency tracheostomy (ET)

Table 2: Airway devices used in patients during resuscitation for in hospital cardiac arrest, n=598. Numbers are counts.

	1st airway	2nd airway	3rd airway	Total
Basic airway*	560	0	2	562 (94%)
TT	1	279	21	301 (50%)
SGA	0	99	3	102 (17%)
ET	1			1 (0.2%)
None	36			36 (6%)

*Basic airway includes bag-mask, nasopharyngeal, oropharyngeal, pocket mask or any combination of these devices.

ET=Emergency tracheostomy; TT=tracheal tube; SGA=supraglottic airway.

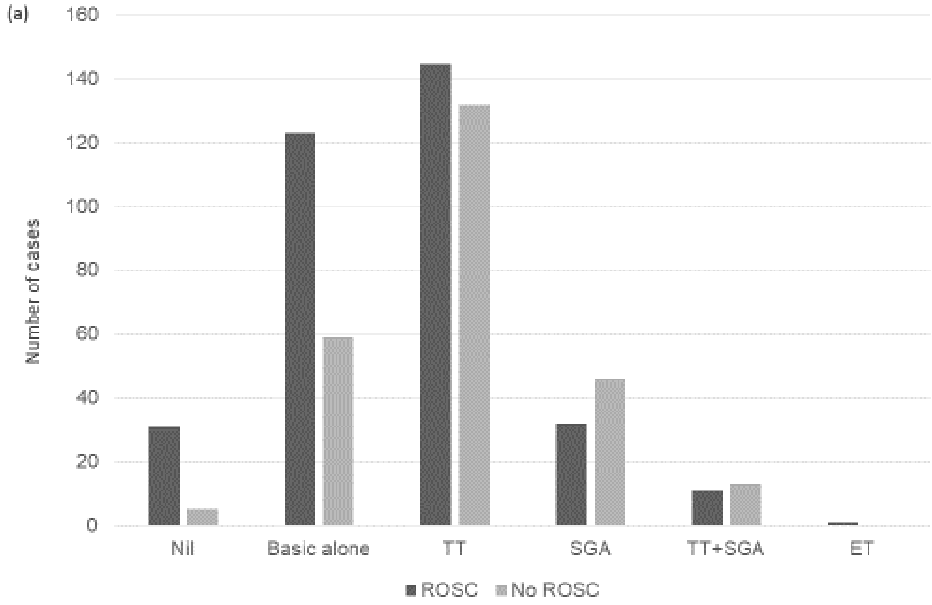
Table 3: Airway devices used during in hospital cardiac arrest by participating centre. (%) refers to the total number of patients at each site (rows 1-5) or in the study (Total). Multiple patients received more than one airway intervention.

Hospital ID	Basic airway at any stage	Basic airway alone	TT	SGA	2nd advanced airway	ET	None
1	98 (97%)	46 (46%)	21 (21%)	40 (40%)	9 (9%)	0 (0%)	3 (3%)
2	113 (93%)	38 (31%)	29 (24%)	54 (45%)	8 (7%)	0 (0%)	8 (7%)
3	107 (98%)	9 (8%)	98 (90%)	3 (3%)	3 (3%)	0 (0%)	2 (2%)
4	157 (100%)	62 (39%)	95 (61%)	4 (3%)	4 (3%)	0 (0%)	0 (0%)
5	85 (77%)	27 (25%)	58 (53%)	1 (1%)	0 (0%)	1 (1%)	23 (21%)
Total	560 (94%)	182 (30%)	301 (50%)	102 (17%)	24 (4%)	1 (0.2%)	36 (6%)

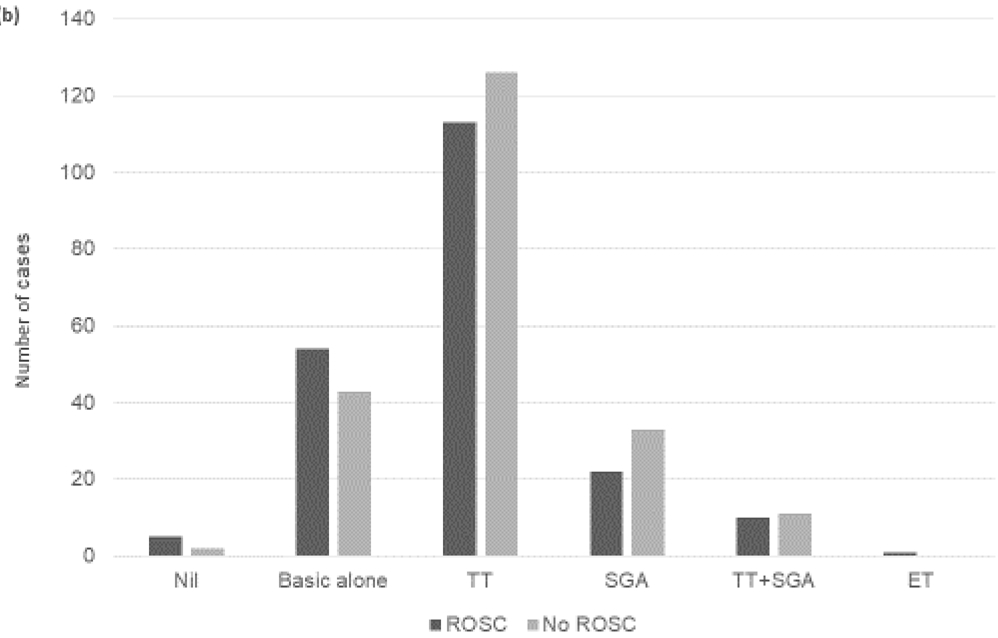
Table 4. Logistic regression of predictor variables included in the model for immediate survival in patients who progressed to receive a second, advanced airway device.

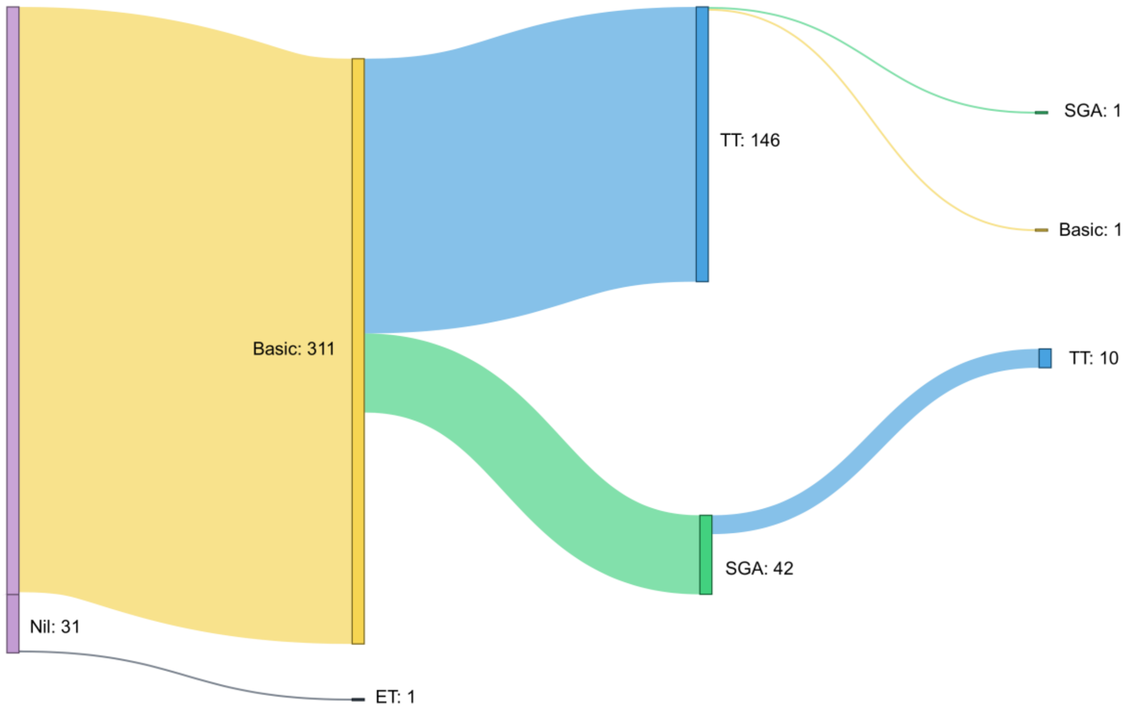
	B	SE	P-value	Odds ratio (95% CI)
Age	-0.038	0.10	<0.001	0.97 (0.95-0.98)
Witnessed (Y/N)	0.85	0.345	<0.001	2.8 (1.7-4.7)
Shockable rhythm (Y/N)	0.76	0.332	0.001	2.6 (1.5-4.5)
Airway (TT/SGA)	0.20	0.405	0.42	0.81 (0.35-1.8)

B= B coefficient; SE=standard error; CI = confidence interval


(a)
160
140
120
100
80
60
40
20
0
Number of cases
Nil
Basic alone
TT
SGA
TT+SGA
ET
ROSC
No ROSC

(b)


140
120
100
80
60
40
20
0
Number of cases
Nil
Basic alone
TT
SGA
TT+SGA
ET
ROSC
No ROSC


SGA: 1
TT: 146
Basic: 1
Basic: 311
TT: 10
SGA: 42
Nil: 31
ET: 1